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SOIL ACIDITY IN RELATION TO INSECTS AND PLANTS

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In pursuing certain entomological studies it became necessary to devise ways and means to grow certain plants of acid soils for the purpose of rearing insects. A method of acidulating soils was used that may have some practical value, and which Dr. Britton informs me appears to be somewhat of a novelty. Since insects and plants are, in a way, so closely related in their affiliations, one may often draw logical conclusions about the distribution of plants or their ecological association by the insects which make use of them as food. In the life history study of insects the food habit is generally a center about which one must largely work.

Some years ago a Rhododendron insect, *Leptobyrsa explanata* Heid., became of considerable economic importance in our section of the country in its attacks on the cultivated varieties of Rhododendron, and our office was asked to find a remedy. Since the insect was indigenous, a first-hand study of its habits was advisable, and a visit to the wild section of Sullivan County, New York, gave opportunity to observe it on the native *Rhododendron maximum.* A remedy for the insect was easily devised, but a feature connected with the growth of the native Rhododendron remained fresh with me. Fifty years before that country had been lumbered over, the growth of hemlock cut and peeled for tanbark, and the trunks left to decay where they had fallen. Occasionally a strip of rotten hemlock mold yet marked the position of an especially fine tree, and there would always be a fringe of Rhododendron and laurel seedlings springing up at the edge of the decomposing pile. Surely a desiccated hemlock contained something advantageous to the growth of such Ericaceous types as these.

One other instance in a similar way pointed to another type of plants and their so-called tannic acid propensities. In the Pine Barrens of New Jersey, near Lakewood, a few pitcher plants, *Sarracenia purpurea,* were found that contained in the roots boring larvae, certainly the early stage of some very interesting adult moth. The generic position of the caterpillar was clear, and their rearing would establish new facts and records. It was one of those chances that happen rarely and the rearings must be completed at all hazards. But these larvae required several weeks for further development, and how could pitcher plants be kept growing in an artificial vivarium so that a fresh undisturbed plant would be at hand when required by a hungry larva?

This pine barren country is for the most part a great stretch of white sand, but the brooks and streamlets run brown with the suspended tannin they get from the decomposition in the cedar swamps. Clearly it is not the kind of sand, but the brown bog water, which was especially necessary to flourishing pitcher plants. Since it was not convenient to import bog water, artificial means had to be used. Through those means, which proved successful in providing sufficient growing plants, specimens of a pretty species of moth, *Papaipema appassionata* Harv., known for thirty years by a unique type in the British Museum, obtained at London, Ontario, was now bred so it may be represented in any museum needing it.

These instances happened many years ago, and subsequently quite a little experimentation in artificial acidulation, necessary for certain types of plants, has been carried on. Now, Nature's workshop is rather slow in producing so-called acid soil conditions, and over limestone formations it may be hard to pass the neutral point to any considerable degree of acidity. The vegetable decay sufficient to influence an acid soil flora has to meet with exceptional conditions, both as to the kind of vegetable decomposition and as to the ground formation, where the excessive amount of acidity needed by certain of the most pronounced types is attained.

In the case of the Orchidaceae, Wherry[1] has worked out an interesting table of the acid intensity of the soil at the roots of many of the eastern United States species. A few of the tall-stemmed cypripediums it appears will stand a slight alkalinity, but all others demand an acid reaction of greater or lesser intensity. Taking one as a neutral point, some species of habenaria flourish in so strong an acid medium as from 300 to 3,000 points above neutral, and he comes to a conclusion, which also independently occurred to me, that the great degree of moisture one might think necessary to some species is not nearly so important as sufficient acidity.

As typical of these extreme types the pitcher plants, Sarracenia, are a good example. The great interest they furnish in studying the insect life succumbing to—and on the other hand flourishing upon—them, their peculiarity of exuding fluid which contains enzymes somewhat similar to the intestinal digestive fluids of animals, makes them desirable plants for laboratory research. An entomologist and a chemist, Jones and Hepburn, have recently proven that certain dipterous larval forms which live upon the decomposing insects caught in the pitcher tubes, and subject to the effects of the digestive fluid exuded by the leaf for the purpose of breaking down these dead insects, find themselves immune because of certain anti-enzymes contained in their chitinous body covering. It is an exact parallel to what occurs with the parasitic worms which live in the intestinal tracts of animals, and which have immunity in exactly the same way.

Since the pitcher plants are notoriously difficult to transplant from their native haunts, they seemed favorable types upon which to try out the extract treatment we had in mind. If good results could be reached in the most obstinate cases, so much the better. The most difficult of all, the Californian Chrysamphora, or as I know it more familiarly, Darlingtonia, happened to come to hand in some insect studies, and seemed especially worthy a trial. In looking up its record I found that it seems never to have been successfully grown in America, or in fact anywhere, except at the Botanical Gardens at Berlin, where it was carried from seed to flower—requiring a period of seven years to come to maturity, according to my information. At the University of Pennsylvania, where certain experiments requiring growing plants were under way, they could never keep these plants alive for more than a few months. Hence if our contemplated acidulation is of value, favorable results with Darlingtonia would be encouraging. A few plants which had been received from California by mail, but with scarcely any soil, were kept alive without special pains for a year, though it must be admitted they did not flower nor luxuriate to any extent. The results, however, in view of the lack of success by others, were reassuring.

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[1] Jour. Wash. Acad. Sci., Nov., 1918.

The eastern Sarracenia all appear more adaptive; *purpurea* and *flava* have been growing continuously with me in artificial media for many years, the former blossoming regularly, while *drummondii* for a shorter period has grown satisfactorily and has flowered. *Psittacina* seems the most obstinate and is, I assume, the nearest species to its Californian relative.

It is our understanding of the acid soil conditions under discussion that this particular acidity is largely an antiseptic property—a condition unfavorable to the growth of ordinary soil bacteria and of spores commonly airborne. The use of Sphagnum moss in war-time surgery, and its feeding to horses given chronically to colic, are crude uses of a natural product retaining what we may call some of the medicinal properties of its environment. While in such soils the usual multitudinous bacteria and fungi do not flourish, yet some particular kinds do live there; a particular species grows on the roots of Rhododendron, and doubtless some such are necessary to all the types of plants we are considering. So it appears that, given a proper medium and inoculation from the acceptable bacteria, we will have a situation where acid soil plants may grow, other factors being also favorable. In the last analysis it becomes a question of the easiest and most practical way of producing a right medium. In nature this seems to be produced by some form of tannin.

The decomposing hemlocks in Sullivan County, which had been sacrificed for the leather trade, suggested that the present-day extract of hemlock bark, as prepared for leather tanning, would prove a means for properly acidulating ordinary soils, since it is easily soluble in water and offers this quick mode of application. In our experiments this seems to work very satisfactorily, and we have discarded chestnut sawdust and rotten wood, make no more arduous trips to peaty swamps, and have long forgotten the kinds of chemicals once used to neutralize such quantities of lime as exist in our shore front soils.

Given a plant transported with some native soil on its roots, so that a sufficient inoculation of the new site may take place, hemlock extract diluted from 50 to 100 parts in water seems to render any common soil a proper medium in a comparatively short time. It must be remembered, however, that the extract is in no way a plant food; the bacteria adaptable to such contact must have the proper ingredients to break down if the plant is to do more than merely exist.

Now, what do the chemists tell us concerning the hemlock bark extract? Dr. Blackadder, of the chemical staff of the Smethport company, reports that his product contains almost exactly 27 percent of tannic acid, so called, the term "tannic acid" being, however, a trade term applied to that portion whereof a little more than one fourth is absorbed by hides in the formation of leather. The exact constitution is very much in question, and the term acid is by no means indicative of a pronounced acid nature. It is really more in the line of an amphoteric. Its action on litmus is mainly due to small quantities of organic acids, and acetic acid is present to the extent of .05 of 1 percent. Dr. Blackadder says: "Where extracts are dissolved in water, a further production of acid goes on for two reasons. Firstly, the so-called tannic acid content undergoes a splitting up of sugars and other acid bodies which are probably more acid than the original. Secondly, there is present in the extract a number of sugars which undergo fermentation, and under favorable circumstances develop a marked amount of acid. This would probably occur when an extract was mixed with a soil which was moist."

So inferentially, under what are commonly termed growing temperatures, we can assume that a soil irrigated with dilute extract may shortly arrive at a condition similar to that produced under nature, without the lengthy period following the breaking down and dissolution of tannin-containing vegetable tissues.

In flower-pot culture or other isolated cases the value of dilute hemlock bark extract has been demonstrated beyond doubt in growing many ferns, some of the native orchids, various bog plants, azalias, etc. We have to admit, however, that practical aims largely influenced the work, and one of the chief results sought was the betterment of conditions in growing Rhododendrons. It was at one time thought that the extreme "winter-killing" which is so severe with certain of the hybrid species might be helped if the plants were kept in a healthier condition through acidulation. While this is true in a way, winter-killing seems a question of transpiration entirely, and the only success secured for the method was that badly affected plants which otherwise would succumb could be restored. Its application to established plantings has shown such varying results that some questions of its practicability yet remain open.

In bog-gardening, hemlock extract treatment for acidulating soils seems to work noticeable results. If we are behind European tastes in this line, it is time we progressed, for the American flora can bountifully provide an ample array of desirable plants. A small experimental spot may be no larger than 6 by 6 feet. This area is chosen because it may be advantageous to make an arrangement something like a hot-bed frame, and because it can be protected in winter by a couple of hot-bed sashes. With such protection the growing season is lengthened, a moister atmosphere can be provided, the Southern species of Sarracenia, etc., carried, while shade in the hot days of midsummer is the more easily provided. As the finished ground line of the little contemplated bog had best be 18 inches below the surface level, an excavation down to three feet or more has to be made. Eight inches of puddled clay is to form the basin, though nature generally provides a much greater depth. Then come eight inches of sand and wood soil in equal parts, if the latter is procurable, in which to make the plantings. If the plot is finished a little lower in the center, plants requiring much moisture, like Sarracenia, can be placed there, making the drier borders available for orchids and the various types that readily suggest themselves. A wooden frame-work around the top, fashioned to receive the sliding sashes, will keep out surface water or the undesirable falling in of the adjoining foreign soil; chestnut or cypress are desirable lumber for this purpose. A cement basin is unsuitable because it gives up lime for a long time and because stagnation is undesirable. In applying the extract to such a bed favorable results have followed weekly applications of ten gallons of water, containing the extract diluted one part to fifty; in such other watering as was necessary ordinary water was used.

What applies on a small scale can doubtless be worked out in larger efforts, and I feel that the bark extract will prove an adjunct to insure success in such ventures. A wide field of usefulness suggests itself in greenhouse work, for the tropical orchids and all epiphytes must in a way be tannin-loving plants.